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Effect of trapped air on the crashworthiness of aluminum honeycomb structures

Overview

This master thesis has the aim to implement the effect of trapped air in a honeycomb structure when a crash occurs in a LS-DYNA model. This can be done using Arbitrary Lagrangian-Eulerian Finite Element Techniques but the computation time is too large. For this reason, a pore air material model has been used in order to achieve accuracy of results with a low cost of computation time.

By doing a review of the theory, experimental tests in order to create the material cards, and a study of the effect of trapped air, an accurate model has been done with the air effects.

Honeycomb

Material in LS-DYNA

Honeycomb in LS-DYNA is modeled with anisotropic behaviour with a non-linear spring in all three principal directions. Three surfaces are considered.

- First: axial direction with elasto-plastic behaviour.
- Second: Transversely isotropic.
- Third: Increase shear resistance of second surface.

The elastic modulus for each direction reads:

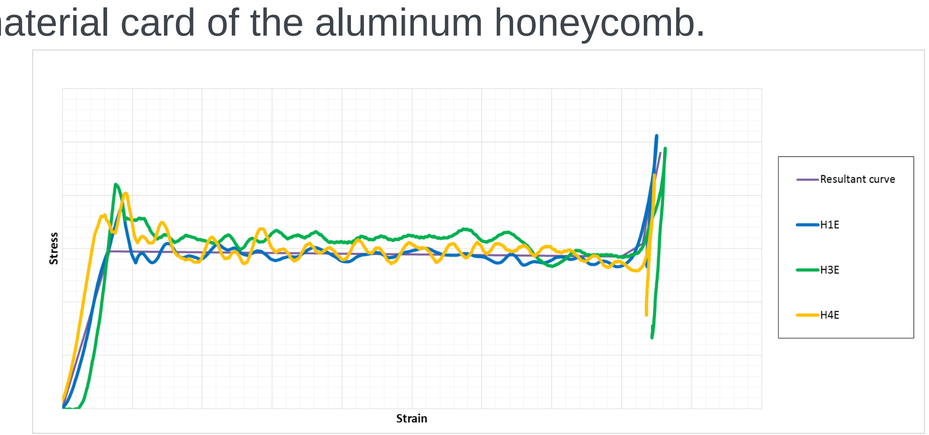
$$E_{aa} = E_{aau} + \beta_{aa}(E - E_{aau})$$

And the stress update is:

$$\sigma_{aa}^{n+1^{trial}} = \sigma_{aa}^{n} + E_{aa}\Delta\varepsilon_{aa}$$

Material test

Different static and at different strain-rate test have been performed in axial and lateral direction in order to obtain the material card of the aluminum honeycomb.



Static compression test results. Data courtesy of UPC ecoRacing.

Honeycomb yields at 2.6*MPa* with 70% of stroke compressed and is strain-rate independent.

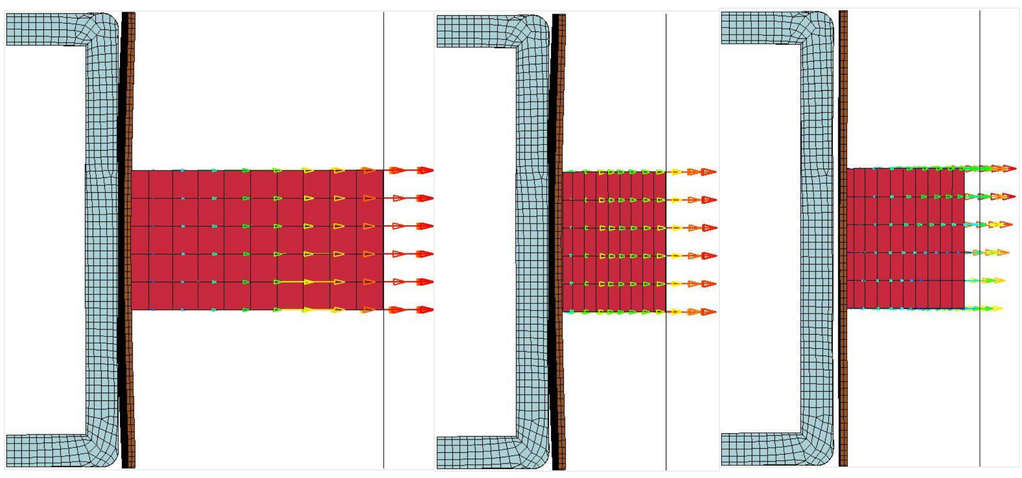
Effect of trapped air

Using the first law of thermodynamics, it has been estimated that the effect of trapped air is of 27% of the peak deceleration of the study case.

By using the material card “ADD_PORE_AIR”, the trapped air has been implemented in the studied model. Volume of air in honeycomb, atmospheric pressure and temperature have been calculated. Also porosity and permeability of air on honeycomb have been implemented.

Results

When the simulation is done, it can be seen the seepage vectors of air escaping from the honeycomb.



Pressure seepage vector evolution. LS-PrePost.

Also a comparison of the simulated and real test can be done in terms of deformation.

Finally, in the table results of acceleration, deformation and energy can be checked.

Case	Peak Acc. (G)	Average Acc. (G)	Absorbed E. (J)	Def. (mm)
Test	23.40	14.63	7500	1.00
No Air	20.8	15.45	7230	0.52
Air	22.55	15.50	7450	0.96

Comparision results. Data courtesy of UPC ecoRacing.

Conclusions

By implementing porosity in aluminum honeycomb, it can be simulated the effect of trapped air and achieve a more accurate model to the reality than the model without air.

Bibliography

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